November 10, 2014

FOUNDATION INVESTIGATION AND DESIGN REPORT

SAND/SALT STORAGE STRUCTURE
GRAVENHURST PATROL YARD
HIGHWAY 11, TOWNSHIP OF MUSKOKA
ASSIGNMENT NO. 3, AGREEMENT NO. 5013-E-0034
MINISTRY OF TRANSPORTATION, ONTARIO
W.O. 2014-11033

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Ministry of Transportation, Ontario
Pavements and Foundations Section
447 McKeown Avenue, Suite 301
North Bay, ON P1B 9S9

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REPORT

Table of Contents

LIST OF APPENDICES

PART A

FOUNDATION INVESTIGATION REPORT
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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by The Ministry of Transportation, Ontario (MTO), Northeastern Region to provide foundation engineering services for a proposed structure at the existing Gravenhurst Patrol Yard, located approximately 500 m south of Muskoka Road 169 (Bethune Drive) on Highway 11 in the Geographic Township of Muskoka. This work has been carried out under the Retainer Assignment under Agreement #5013-E-0034.

The purpose of this investigation is to establish the subsurface conditions at the proposed Patrol Yard sand/salt storage structure by methods of borehole drilling, in situ testing and laboratory testing on selected samples. The location of the structure was determined in the field by Golder based on the Patrol Facility Site Plan drawing (Plan H-395-11-1, dated 2013 02), which was included in the Terms of Reference for this work. The approximate location of the proposed structure within the existing Patrol Yard facility is shown in plan on Drawing 1.

2.0 SITE DESCRIPTION

The proposed sand/salt storage structure will be 15.2 m by 24.4 m in plan dimensions and will be built within a cleared area in the existing patrol yard facility.

In general, the topography in the vicinity of the proposed structure is flat and the ground surface at the structure location varies between about Elevation 256 m and 257 m. Various materials storage piles/mounds (asphalt, sand, etc.) are present in the general area of the proposed sand/salt storage facility. A detailed description of the subsurface conditions at the structure location is presented in Section 4.0.

3.0 INVESTIGATION PROCEDURES

3.1 Foundation Investigation

The investigation for the storage structure was carried out between September 2 and 5, 2014, during which time a total of four boreholes were advanced within the footprint of the proposed structure. The locations of the boreholes are shown on Drawing 1 and the coordinates are provided on the Record of Borehole sheets in Appendix A.

The field investigation was carried out using a track-mounted D55 Turbo drill rig supplied and operated by Walker Drilling Ltd. of Utopia, Ontario. The boreholes were advanced through the overburden using 108 mm inner diameter hollow-stem augers. In general, soil samples were obtained at depth intervals of 0.75 m and 1.5 m, using a 50 mm O.D. split-spoon sampler driven by an automatic hammer and carried out in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586, Standard Test Method for Standard Penetration Test). All boreholes were backfilled with bentonite and cuttings upon completion in accordance with Ontario Regulation 903 Wells (as amended).

The boreholes were advanced to depths ranging between 11.3 m and 12.8 m below existing ground surface.

The groundwater conditions and water levels in the open boreholes were observed during the drilling operations and are described on the Record of Borehole sheets provided in Appendix A.

The fieldwork was observed by a member of our engineering and technical staff, who located the boreholes, arranged for the clearance of underground services using Ontario One Call and a private locator, observed the drilling, sampling and in situ testing operations, logged the boreholes, and examined and cared for the soil samples. The samples were identified in the field, placed in appropriate containers, labelled and transported to our Sudbury Geotechnical Laboratory where the samples underwent further visual examination and laboratory testing. All of the laboratory tests were carried out to MTO and/or ASTM Standards, as appropriate. Classification testing (water content, grain size distribution and Atterberg limits) was carried out on selected samples. The results of the laboratory testing on samples from the boreholes are presented on the Record of Borehole sheets and are included in Appendix B.

The location of the structure was provided by the MTO on the Patrol Facility Site Plan drawing (Plan H-395-11-1, dated 2013 02). Our staff determined the structure location in the field by referencing the plan and measuring distances from easily identifiable known points. The boreholes were located in the field as close to the four corners of the structure footprint as practical based on existing site access conditions. The UTM coordinates of the as-drilled borehole locations were recorded with a handheld GPS (accuracy to ± 3 m) using NAD 83 datum. The borehole coordinates were subsequently converted into MTM NAD 83 in AutoCAD. Borehole elevations were surveyed by a member of our technical staff in reference to the ground surface elevation at an existing benchmark (GBM 271-67) located on an existing concrete garage within the facility. The borehole locations given in the Record of Borehole sheets and shown on Drawing 1 are positioned relative to MTM NAD 83 northing and easting coordinates and the ground surface elevations are referenced to Geodetic datum. The borehole locations, ground surface elevations and drilled depths are as follows:

Borehole	Location (MTM NAD 83)		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing	Easting		
BH-YARD1	4 973 399.2	315 563.8	256.4	11.3
BH-YARD2	4 973 379.0	315 663.4	256.4	11.3
BH-YARD3	4 973 372.9	315 656.4	256.6	12.8
BH-YARD4	4 973 390.3	315 642.6	256.8	12.8

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

Based on published geologic information, made publically available from the Ontario Ministry for Northern Development and Mines[1] through “OGS Earth”, the surficial soils in the vicinity of the patrol yard generally consist of coarse-textured glaciolacustrine deposits of gravel and sand with minor amounts of silt and clay. Based on available information, the patrol yard may have been used as a sand and/or gravel pit. Published information from the Ontario Ministry for Northern Development and Mines[2] through “OGS Earth” indicates that the patrol yard is located in the Central Gneiss Belt of the Grenville Province, which contains rocks from 1.0 Ga to 1.6 Ga in age, consisting primarily of zones of mafic, igneous, migmatitic and metasedimentary rocks.

[1] Ontario Geologic Survey. 2003. Surficial Geology of Southern Ontario. Ontario Ministry of Northern Development and Mines.

[2] Ontario Geologic Survey. 2000. Bedrock Geology, Seamless Coverage of the Province of Ontario. Ontario Ministry of Northern Development and Mines.

4.2 General Overview of Local Subsurface Conditions

The detailed subsurface soil and groundwater conditions as encountered in the boreholes advanced during this investigation, together with the results of the laboratory tests carried out on selected soil samples, are presented on the attached Record of Borehole sheets in Appendix A and the soil laboratory test sheets provided in Appendix B. The results of the in situ field tests (i.e., SPT 'N'-values) as presented on the Record of Borehole sheets and in this section are uncorrected. The stratigraphic boundaries shown on the Record of Borehole sheets are inferred from non-continuous sampling, observations of drilling progress and the results of in situ testing. These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. Further, subsurface conditions will vary between and beyond the borehole locations.

In general, the subsurface conditions encountered at the site consist of compact to very dense sandy gravel to sand fill at the ground surface underlain by a non-cohesive deposit of compact to dense sand in turn underlain by a deposit of loose to compact sandy silt to silt and sand with occasional layers of clayey silt and silt. All boreholes were terminated within the sandy silt to silt and sand deposit. Detailed descriptions of the subsurface conditions are provided in the following sections of this report.

4.2.1 Fill

Fill comprised of brown to black sandy gravel, sand and gravel and/or sand was encountered at the ground surface in all boreholes. The fill deposit was encountered between Elevation 256.8 m and Elevation 256.4 m and is between 3.6 m and 3.7 m thick. The fill material in Boreholes BH-YARD2 to BH-YARD4 contained gravel sized pieces of asphalt in the upper 0.6 m to 1.5 m.

SPT 'N'-values measured within the fill range from 10 blows to 87 blows per 0.3 m of penetration indicating a compact to very dense relative density.

The natural water content measured on thirteen samples of the sandy gravel to sand fill stratum ranges from about 2 per cent to 12 per cent.

The results of grain size distribution tests completed on seven samples of the fill are shown on Figure B1 in Appendix B.

4.2.2 Sand

A non-cohesive deposit consisting of brown sand, trace silt was encountered underlying the fill in all boreholes. The surface of the deposit was encountered between Elevation 253.1 m and Elevation 252.7 m and the thickness of the stratum ranges from 5.0 m to 5.1 m.

SPT 'N'-values measured within the sand stratum range from 24 blows to 46 blows per 0.3 m of penetration indicating a compact to dense relative density.

The natural water content measured on nine samples of the sand stratum ranges from about 18 per cent to 23 per cent.

The results of grain size distribution tests completed on four samples of the sand stratum are shown on Figure B2 in Appendix B.

4.2.3 Sandy Silt to Silt and Sand

A deposit of brown to grey wet sandy silt to silt and sand, trace clay was encountered underlying the sand stratum in all boreholes. Silt and clayey silt to silt layers were noted within the silt and sand portion of the deposit in Boreholes BH-YARD3 and BH-YARD4. The surface of the deposit was encountered between Elevation 248.1 m and Elevation 247.7 and was not fully penetrated beyond a thickness of 2.6 m to 4.1 m.

SPT 'N'-values measured within the deposit range from 5 blows to 26 blows per 0.3 m of penetration indicating a loose to compact relative density.

The natural water content measured on seven samples of this deposit ranges from about 19 per cent to 25 per cent.

The results of grain size distribution tests completed on four samples of this deposit, including the silt layer, are shown on Figure B3 in Appendix B.

Cohesive material was encountered at a depth of about 10.7 m below ground surface (Elevation 246.1 m to Elevation 245.9 m). Atterberg limits tests were carried out on the two samples of the layer in Boreholes BH-YARD3 and BH-YARD4 and measured liquid limits of about 20 per cent and 23 per cent, plastic limits of about 16 per cent to 18 per cent and plasticity indices of about 3 per cent and 7 per cent. The results of the Atterberg limits tests are shown on the plasticity chart on Figure B4 in Appendix B and indicate the material in this zone is classified as a silt of slight plasticity and clayey silt of low plasticity in the respective boreholes.

4.3 Groundwater Conditions

Groundwater levels were measured in the open boreholes during and upon completion of drilling at depths ranging from 3.8 m to 4.3 m below ground surface or between Elevation 252.8 m and Elevation 252.3 m, which roughly corresponds to the depth where the field moisture condition of the material changed from moist to wet.

Groundwater elevations as encountered in the boreholes may not be representative of static groundwater levels since the groundwater levels in the boreholes may not have stabilized on completion of drilling. Furthermore, groundwater elevations will vary depending on seasonal fluctuations, precipitation and local soil permeability.

5.0 CLOSURE

The drilling program was supervised by Mr. David Marmor, EIT. This report was prepared by Mr. David Marmor and reviewed by Ms. Sarah E. M. Poot, P.Eng., a senior geotechnical engineer and Associate with Golder. Mr. Jorge M. A. Costa, P.Eng., Golder's Designated MTO Contact for Foundations for this assignment and Principal with Golder, conducted an independent quality control review of the report.

Report Signature Page

GOLDER ASSOCIATES LTD.

David Marmor, EIT
Geotechnical Engineering Intern

LICENSED PROFESSIONAL ENGINEER
S. E. M. POOT
90471921
11/10/14
PROVINCE OF ONTARIO

Sarah E.M. Poot, P. Eng.
Senior Geotechnical Engineer, Associate

LICENSED PROFESSIONAL ENGINEER
J. M. A. COSTA
NOV10/14
PROVINCE OF ONTARIO

Jorge M.A. Costa, P. Eng.
Designated MTO Contact, Principal

DPM/SEMP/JMAC/kp

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PART B

FOUNDATION DESIGN REPORT
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6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

This section of the report provides foundation design recommendations for the proposed Patrol Yard sand/salt storage structure. The recommendations are based on interpretation of the factual data obtained from the boreholes advanced during the foundation investigation at the site.

The interpretation and recommendations presented are intended to provide the designers with sufficient information to assess the feasible foundation alternatives and to design the proposed structure foundations. Where comments are made on construction, they are provided in order to highlight those aspects which could affect the design of the project, and for which special provisions or operational constraints may be required in the Contract Documents. Those requiring information on aspects of construction should make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction methods, scheduling and the like.

6.1 General

Based on the Patrol Facility Site Plan drawing (Plan H-395-11-1, dated 2013 02) included in the Terms of Reference for this work, the proposed sand/salt storage structure will be 15.2 m by 24.4 m in plan dimensions. Based on design drawings for similar structures provided by the MTO and correspondence with MTO, it is understood that the sand/salt storage structure will have a maximum height of about 11.0 m to the bottom of the trusses; the structure will be constructed with 3.8 m high, buttress-supported, cast-in-place concrete walls around the perimeter with pre-engineered timber walls and roof, and will have an asphalt floor slab for the plan area of the facility.

The existing ground surface at the structure location varies between Elevation 256.4 m and 256.8 m. The assumed finished top of floor will be at the current ground level of about Elevation 256.4 m to tie-in to the adjacent exterior paved areas.

In general, the subsurface conditions encountered at the site consist of up to 3.7 m of compact to very dense sandy gravel to sand fill at the ground surface underlain by an approximately 5 m thick non-cohesive deposit of compact to dense sand, in turn underlain by a deposit of loose to compact sandy silt to silt and sand with occasional layers of clayey silt and silt. The unstabilized groundwater level was measured within the compact to dense sand deposit between 3.8 m and 4.3 m below ground surface.

6.2 Foundations

Based on the subsurface conditions at this site and given that bedrock or very dense material was not encountered within the borehole termination depth (i.e., to 11.3 m below ground surface), deep foundations are not considered to be a practical foundation option since the founding strata within which piles or caissons will terminate will provide low axial resistances and the foundations will experience settlement under the proposed loading. We recommend that the sand/salt storage structure be supported on shallow foundations comprised of strip/spread footings founded on/within the native compact to dense sand deposit, or on free draining engineered fill, such as OPSS.PROV 1010 (Aggregates) Granular 'A' or Granular 'B', Type I or Type II, constructed as described in Section 6.6 as a replacement for the existing fill. Alternatively, the strip/spread footings may be founded on the compact to dense sand to sandy gravel fill. Strip or spread footings founded at shallow depth either within the fill deposit, on the surface of the native sand deposit, or on engineered fill constructed as replacement of the existing fill can likely be constructed using conventional methods as such a founding depth is above the water table as observed in the boreholes during the subsurface investigation.

It must be recognized that there will be variability in the composition and relative density of the existing fill stratum as it is not known/documented whether the existing compact to dense sand to sandy gravel fill at the site was placed and compacted in accordance with a standard suitable for construction of the fill as engineered fill and hence to assess for the potential impact on shallow strip/spread footings founded within this stratum. Founding strip/spread footings within the existing compact to dense sand to sandy gravel fill is the least preferred foundation option. However, the footing subgrade founded within the existing fill is inspected by a Quality Verification Engineer (QVE) following excavation, in accordance with OPSS 902 (Excavating and Backfilling - Structures) and approved, this may prove an economical option when compared to the other two options of founding the footings on engineered fill or on the surface of the native sand stratum.

If the geotechnical resistances provided below for strip/spread footings are not sufficient for the design of the structure and a deep foundation option is required, additional boreholes extending to greater depths and potentially to refusal would be required.

6.2.1 Footing Elevation

Strip or spread footings should be founded on engineered fill constructed as replacement for the existing fill or on the surface of the native compact to dense sand deposit but may also be founded within the existing compact to dense sand to sandy gravel fill deposit. The following founding elevations for the underside of strip or spread footings are recommended for design. These founding elevations should be checked relative to the adjacent grades to ensure they are a minimum 1.7 m below the lowest surrounding final grade, to provide adequate protection against frost penetration (see Section 6.2.4). Recommendations for engineered fill construction are provided in Section 6.6.

Soil Deposit at Founding Depth	Maximum (Highest) Founding Elevation	Depth Below Existing Grade
Engineered Fill over Native Sand	254.7 m	1.7 m to 2.1 m (requires excavation to Elevation 252.7 m and up to 2.0 m of Engineered Fill)
Compact to Dense Sand	252.7 m	3.7 m to 4.1
Compact to Dense Sand to Sandy Gravel Fill	254.2 m	2.2 m to 2.6 m

6.2.2 Geotechnical Resistance

Strip or spread footings placed on the properly prepared subgrade at or slightly below the design elevations given in Section 6.2.1, should be designed based on the factored geotechnical resistances at Ultimate Limit States (ULS) and geotechnical reactions at Serviceability Limit States (SLS) for 25 mm of settlement, given below. Settlement of the footings under the loading from the stockpile, which will happen after footing construction, should also be considered as discussed in Section 6.5.2.

Founding Stratum	Footing Width (m)	Factored Geotechnical Axial Resistance at ULS (kPa)	Geotechnical Reaction at SLS (for 25 mm settlement) (kPa)
Engineered Fill over Native Sand	2	700	350
	3	850	250
Compact to Dense Sand	2	800	350
	3	900	250
Compact to Dense Sand to Sandy Gravel Fill	2	400	300
	3	500	250

The ULS resistance and the settlement are dependent on the footing size, depth of embedment, configuration and applied loads. The geotechnical resistances should, therefore, be reviewed if the selected footing width or founding elevation differs from those given above. In addition, the geotechnical resistances are provided for loads applied perpendicular to the surface of the footings; where applicable, inclination of the load should be taken into account in accordance with Section 6.7.4 of the Canadian Highway Bridge Design Code (CHBDC 2006) and it's Commentary.

The footing subgrade should be inspected by a Quality Verification Engineer following excavation, in accordance with OPSS 902 (Excavating and Backfilling - Structures) to check that the founding elevation is reached and that all unsuitable material, including organic or loose/soft material, has been removed. If the conditions at the time of construction are wet, from rainfall, snow or groundwater, the founding soils may be susceptible to disturbance and if the concrete for the footings cannot be poured immediately after excavation and inspection, it is recommended that concrete working slab be placed on the prepared subgrade within four hours of its inspection and approval. A Non-Standard Special Provision (NSSP) for the working slab should be included in the Contract Documents; an example is provided in Appendix C.

6.2.3 Resistance to Lateral Loads

Resistance to lateral forces/sliding resistance between the base of the concrete footings and the proposed founding material should be calculated in accordance with Section 6.7.5 of the CHBDC. The coefficient of friction, tan δ, for cast-in-place concrete footings on the properly prepared subgrade soils or working slab is provided below. These values assume that construction is carried out in dry conditions. These values represent unfactored values.

Founding Stratum	Footing Type	tan δ (Navfac 1986)
Engineered Fill over Native Sand	Cast-in-place	0.60
Compact to Dense Sand Native Material	Cast-in-place	0.45
Compact to Dense Sand to Sandy Gravel Fill	Cast-in-place	0.60

The following information is provided concerning the structural design of the perimeter walls in the event that the perimeter walls are required to support unbalanced lateral earth pressures resulting from the sand/salt stockpiles being piled against the walls. The structural support of the buildings walls to resist induced loadings from the portion of sand/salt stockpiles placed against the walls inside the building will likely have to be supported by concrete buttresses constructed along the outside of the building. The design of the walls to resist such lateral loads may be based on the geotechnical design parameters (for a triangular lateral earth pressure distribution) as follows:

- Unit weight of sand/salt stockpile material (γ) = 21 kN/m³;
- Height of stockpiled material against the wall (3.7 m at maximum capacity) plus height of sloping material above the wall (assumed to be 4.6 m at maximum capacity at a slope of 1.5H:1V);
- Lateral earth pressure coefficient (K_o) = 0.46 (uncorrected for sloping pile); and
- Coefficient of friction between concrete butress footing and fill or native soils (μ) = tan δ (as above).

6.2.4 Frost Protection

All footings should be provided with a minimum of 1.7 m of soil cover for frost protection (OPSD 3090.101, Foundation, Frost Penetration Depths for Southern Ontario). In addition, the bearing soil and fresh concrete should be protected from freezing during cold weather construction.

6.3 Seismic Site Classification

According to Table 4.1.8.4 A of the Ontario Building Code (2012), the project site is classified as Class D for the observed properties and thickness of the native soils. The four values for the Gravenhurst area of the Spectral Response Acceleration [S_a(T)] for different periods and the Peak Ground Acceleration (PGA) can be obtained from the National Building Code of Canada (2010). The design values of acceleration-based site coefficient (F_a) and velocity-based site coefficient (F_v) for the project site should be calculated in accordance with Tables 4.1.8.4 B and C, respectively, of the Ontario Building Code (2012). Should higher site class designations be required, additional investigation to measure the seismic site response will be required.

6.4 Floor Slab

It is understood that the sand/salt storage structure will have an asphalt floor slab which would be supported on the existing fill deposits or on engineered fill. According to the MTO, the finished floor level will likely match the existing ground surface at approximate Elevation of 256.4 m. The uppermost lift of fill beneath the floor slab should consist of a minimum thickness of 150 mm of OPSS.PROV (Aggregates) Granular 'A' compacted to not less than 100 per cent of the material's standard Proctor maximum dry density (SPMDD).

Where the interior ground floor slab/pavement is at or above the level of the exterior final grade, no perimeter drainage at the footing level is required, however, based on our experience with similar structures, a permanent sub-floor drainage system may be required to collect salt-bearing water and convey it to a holding tank. If required, the drainage system could consist of a system of floor drains and collection pipes draining to designated holding tanks for treatment and/or disposal. In order to minimize contamination into the native soils by run-off water or infiltration containing a high concentration of salts, a barrier should be installed below the sand/salt storage area. Consideration could be given to the use of a compacted low-permeability clay (i.e., bentonite) liner or geosynthetics (i.e., geosynthetic clay liner or geomembrane). The use of a geomembrane has the advantage over compacted clay products in terms of improved performance of the barrier and floor slab system. Details of the geomembrane installation and specifications, collection/drainage pipe type, network layout and size, and quality control/assurance procedures should be provided by the designer of the drainage collection system. Geotechnical recommendations related to the installation of the geomembrane/drainage system are provided below.

The geomembrane should be installed on a minimum 75 mm thick layer of sand fill, meeting the specifications of OPSS.PROV 1004 (Aggregates – Miscellaneous) for Winter Sand, or OPSS.PROV 1002 (Aggregate - Concrete) for Fine Aggregate placed over the subgrade, to protect the geomembrane from angular gravel/cobble pieces that may be contained in the existing fill or engineered fill. Similarly a 300 mm thick layer of winter sand should be placed directly on top of the geomembrane in order to protect it from the overlying pavement structure. The use of a geotextile (instead of sand) adjacent to the geomembrane was considered, however, an adequate factor of safety against global instability of the stockpile for this configuration is not achieved given the low interface friction between the smooth geomembrane and the geotextile.

Care must be taken when placing the sand on top of the geomembrane, during spreading and compacting the sand which should be carried out using a low ground-pressure bulldozer (maximum ground pressure of 35 kPa). The sand cover should be compacted to at least 95 per cent of the material's standard Proctor maximum dry density. A minimum 300 mm thick separation distance must be maintained between the bulldozer tracks and the top of the geomembrane. Truck traffic should be restricted to temporarily thickened areas of the cover soil layer by providing a minimum separation distance of 900 mm between truck tires and the underlying geomembrane. An example NSSP for placement and compaction of soils above the geomembrane is included in Appendix C.

6.5 Stability and Settlement Analysis

6.5.1 Stability

Stability analyses have been performed for the maximum height sand/salt storage pile of 11.0 m, using the commercially available program SLOPE/W produced by Geo-Slope International Ltd (Version 7.23). Effective stress parameters were employed in the analysis, based on the results of the Standard Penetration Tests tempered by engineering judgment based on precedent experience in similar soils. The following summarizes the strength parameters and unit weights employed for the different materials.

Material	Unit Weight (kN/m^3)	Strength Parameters
Fill Underlying Asphalt (sand and gravel) or Engineered Fill	22	c´ = 0 kPa ϕ´ = 35°
Geomembrane	19	c´ = 0 kPa ϕ´ = 16°
Compact to dense sand to sandy gravel fill	21	c´ = 0 kPa ϕ´ = 33°
Compact to dense sand	21	c´ = 0 kPa ϕ´ = 32°
Loose to compact sandy silt to silt and sand	18	c´ = 0 kPa ϕ´ = 28°
Stockpiled Sand/Salt Material	20	c´ = 0 kPa ϕ´ = 33°

Note: The internal friction angle for the geomembrane is based on information supplied by Layfield Geosynthetics.

The stability analyses assume that all topsoil and native soils containing organics have been removed prior to construction, that the concrete side walls in the sand/salt storage area have a minimum founding depth of 1.7 m, sand/salt piled to a maximum height of 3.7 m up the sides of the perimeter walls, that the proposed geomembrane and sand interface has a minimum internal angle of friction of 16 degrees, and that there is a minimum thickness of 0.8 m of free draining granular material between the asphalt pavement and the geomembrane liner (comprised of 150 mm of Granular ‘A’ base course, 350 mm of Granular B Type I or Type II and 300 mm of sand cover over the geomembrane). The results of the stability analyses are as follows:

- A factor of safety greater than 1.3 is obtained for a deep-seated, global type failure surface that could impact the stability of the sand/salt storage structure, for an approximately 8.3 m high stockpile the height of which is governed by the angle of repose of the stockpiled material. The result from a selected stability analysis is presented on Figure 1.
- As the side slopes of the stockpile are governed by the angle of repose of the stockpile material and the height of the pile is dependent on the height of the perimeter walls against which it is placed, the stability of the pile was assessed for the approximate maximum height of placement for the condition of an unrestrained front slope as shown on Figure 2; the stockpile will “fail” surficially and slough to the angle of repose if material is placed to a greater height. A factor of safety greater than 1.3 is obtained for the stockpiled sand sliding along the geomembrane when the height of stockpile is about 8.3 m.

The asphalt floor slab was not included the analysis and will provide additional stability to the system.

6.5.2 Settlement

Settlement analysis has been performed for the sand/salt stockpile loading, assuming a maximum stockpile height of 8.3 m using the commercially available program Settle^{3D} (Version 2.016) produced by Rocscience Inc. as well as hand calculations. The site soils are cohesionless, with the exception of a thin layer of clayey silt to silt of low to slight plasticity which was encountered in Boreholes BH-YARD3 and BH-YARD4 at Elevation 245.9 m and 246.1 m, respectively. Based on the generally cohesionless nature of the soils at the site, significant long-term consolidation settlements are not anticipated.

The elastic compression of the loose to dense subsoils under the sand/salt stockpile loading has been modelled using elastic moduli of deformation based on the measured SPT "N"-values and correlations proposed by Bowles (1984) and CHBDC. The stockpile loadings have been assumed based on a maximum sand/salt pile height of approximately 8.3 m at the centre and 3.7 m along the sides. The estimated settlement under the stockpile is 35 mm at the centre and 18 mm at the edges of the stockpile. The settlement is considered elastic and will occur during loading (i.e., after the footings have been constructed). The design of the footings should consider the settlement under the full stockpile loading.

6.6 Site Preparation and Engineered Fill Construction

Any fill materials required within the building envelope should consist of suitable material placed/compacted to engineered fill standards. All topsoil if encountered and any portions of the cohesionless deposits that are loose/disturbed or contain organics and/or other deleterious materials are not considered to be suitable for the subgrade support of building foundations, floor slabs, or as engineered fill materials. The exposed subgrade should be heavily proof-rolled under the supervision of experienced geotechnical personnel. Any softened/loosened or poorly performing areas of the subgrade soils should be sub-excavated and replaced with engineered fill comprised of free-draining material, such as OPSS.PROV 1010 (Aggregates) Granular 'A' or Granular 'B', Type I or Type II.

The prepared area should encompass the limits of the engineered fill. The engineered fill limits are defined such that the fill extends to at least 1 m beyond the outside edge of the founding level of any footing or other settlement-sensitive area and then downward and outward at a slope of one horizontal to one vertical (1H:1V).

Following proof-rolling and approval of the subgrade, engineer-approved fill should be placed in accordance with OPSS 501 (Compacting) and SP SP105S21. Within the building footprints, the fill should be compacted to 100 per cent of the material's standard Proctor maximum dry density. Filling should continue until the design subgrade elevation is achieved, with full-time inspection and in-situ density testing carried out by a qualified geotechnical engineering firm during placement of engineered fill beneath the structure and settlement-sensitive areas.

As discussed in Sections 6.2 (Foundations) and 6.5 (Stability and Settlement Analysis), the geotechnical recommendations provided for the design of shallow foundations, assessment of stability, and for mitigation of settlement due to the sand/salt pile loadings are based on the use of OPSS.PROV 1010 (Aggregates) Granular 'A' or Granular 'B' Type II fill for the support of the structure footing and the stockpile asphalt slab.

The final surface of the engineered fill should be protected as necessary from construction traffic, and should be sloped to provide positive drainage for surface water during the construction period. If the engineered fill materials will be left exposed (i.e., uncovered) during periods of freezing weather, consideration should be given to placing an additional soil cover above final subgrade to provide for frost protection.

6.7 Construction Considerations

6.7.1 Temporary Excavations

All excavations must be carried out in accordance with the latest edition of the Ontario Occupational Health and Safety Act (OHSA) and Regulations for Construction Projects. The excavations will extend to depths between 1.7 m and 4.1 m below ground surface. In general, the base of excavations to these depths are expected to be above the groundwater level; however, deeper excavations may extend below the groundwater level at the site.

The typically compact to dense sand to sandy gravel fill soil is classified as Type 3 soil according to OHSA. The native soils below the water table would be classified as Type 4 soil unless a suitable dewatering system is installed to lower the water level below the base of the excavation. Temporary excavations above the water table may be made with side slopes no steeper than 1H:1V. Where excavations extend below the groundwater table at the site, the temporary side slopes will have to be formed at 3H:1V unless proper groundwater control is implemented.

It should be noted that the water levels in this area may fluctuate depending on the time of year. It is recommended that excavations for foundations be carried out in late summer when water levels are anticipated to be lower.

If steeper side slopes are necessary, temporary excavation support will be required. Temporary excavation support should be designed and constructed in accordance with OPSS 539 (temporary Protection Systems). The lateral movement of the temporary shoring system should meet Performance Level 2 as specified in OPSS 539.

6.7.2 Groundwater Control

Foundation excavations terminated within the existing sand to sandy gravel fill are expected to be above the groundwater table and dewatering is not expected to be required. For foundations or engineered fill placed on the native sand deposit at or below Elevation 252.7 m, the groundwater level may be encountered as the highest unstabilized groundwater level noted during the foundation investigation was at Elevation 252.8 m but could be higher during wetter periods of the year. In these areas, groundwater control, such as sumps with filter equipped pumps, will be required to control seepage into the excavation from the base and lower sections of the side slopes. Surface water should be directed away from the excavation area at all times. An example of NSSP concerning dewatering of the native soils during excavation and foundation construction is attached in Appendix C.

6.7.3 Obstructions

Although boulders and cobbles were not encountered during the investigation, the potential exists that both are present within the site soils. Conventional excavation equipment should be suitable for the majority of excavation through the on-site soils; however, the recycled asphalt near the surface of the site, noted in BH-YARD2, to BH–YARD4, may interfere with or slow the progress of excavation.

6.7.4 Summary of Required NSSPs

To summarize the preceding discussions, it is recommended that the following Non-Standard Special Provisions (NSSPs) be provided in the Contract Documents to address geotechnical aspects of excavation and foundation construction at this site:

- NSSP regarding placement of a concrete working slab on the foundation subgrade immediately following inspection of the prepared subgrade, to protect the sand/silt soils from disturbance.
- NSSP for supply and installation of sand fill above the geomembrane, and to warn the Contractor of restricted construction activities above the geomembrane.
- NSSP concerning dewatering of the native soils during excavation and foundation construction.

7.0 CLOSURE

This report was prepared by Mr. David Marmor and reviewed by Ms. Sarah E. M. Poot, P.Eng., a senior geotechnical engineer and Associate with Golder. Mr. Jorge M. A. Costa, P.Eng., Golder's Designated MTO Contact for Foundations for this assignment and Principal with Golder, conducted an independent quality control review of the report.

Report Signature Page

GOLDER ASSOCIATES LTD.

David Marmor, EIT
Geotechnical Engineering Intern

LICENSED PROFESSIONAL ENGINEER
S. E. M. POOT
90471921
11/10/14
PROVINCE OF ONTARIO

Sarah E.M. Poot, P. Eng.
Senior Geotechnical Engineer, Associate

LICENSED PROFESSIONAL ENGINEER
J. M. A. COSTA
NOV10/14
PROVINCE OF ONTARIO

Jorge M.A. Costa, P. Eng.
Designated MTO Contact, Principal

DPM/SEMP/JMAC/kp

\\Golder.gds\gal\Whitby\Active_2014\1181- Geotechnical & Pavement\14-1181-0014 MTO EOI 5013-E-0034 NER Retainer\Assignment 3\Report\Patrol Yard Structure FIDR\Final\14-1181-0014-3000 RPT 14Nov10 FIDR Patrol Yard Structure.docx

REFERENCES

Bowles, J.E., 1984. Physical and Geotechnical Properties of Soils, Second Edition. McGraw Hill Book Company, New York.

Canadian Highway Bridge Design Code (CHBDC) and Commentary on CAN/CSA S6-06, 2006. CSA Special Publication, S6.1-06. Canadian Standard Association.

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Unified Facilities Criteria, U.S. Navy. 1986. NAVFAC Design Manuals 7.01 and 7.02. Soil Mechanics, Foundation and Earth Structures. Alexandria, Virginia.

ASTM International

ASTM D1586 Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils

Commercial Software

GeoStudio (Version 7.23) by Geo-Slope International Ltd.

Settle 3D (Version 2.016) by Rocscience Inc.

Ministry of Transportation Ontario Special Provisions

SP 105S21 Amendment to OPSS 501, November 2010 – Water Requirements and Quality Control for Compaction – Method B.

Ontario Provincial Standard Drawings

OPSD 3090.101 Foundation, Frost Penetration Depths for Southern Ontario

Ontario Provincial Standard Specifications

OPSS 501 Construction Specification for Compacting

OPSS 539 Construction Specification for Temporary Protection Systems

OPSS 902 Construction Specification for Excavating and Backfilling - Structures

OPSS.PROV 1002 Materila Specification for Aggregates – Concrete

OPSS.PROV 1004 Material Specification for Aggregates – Miscellaneous

OPSS.PROV 1010 Material Specification for Aggregates – Base, Subbase, Select Subgrade and Backfill Material

Ontario Water Resources Act

Ontario Regulation 903/90 Wells: O. Reg. 468/10 Amendment to Ontario Regulation 903

MINISTRY OF TRANSPORTATION, ONTARIO

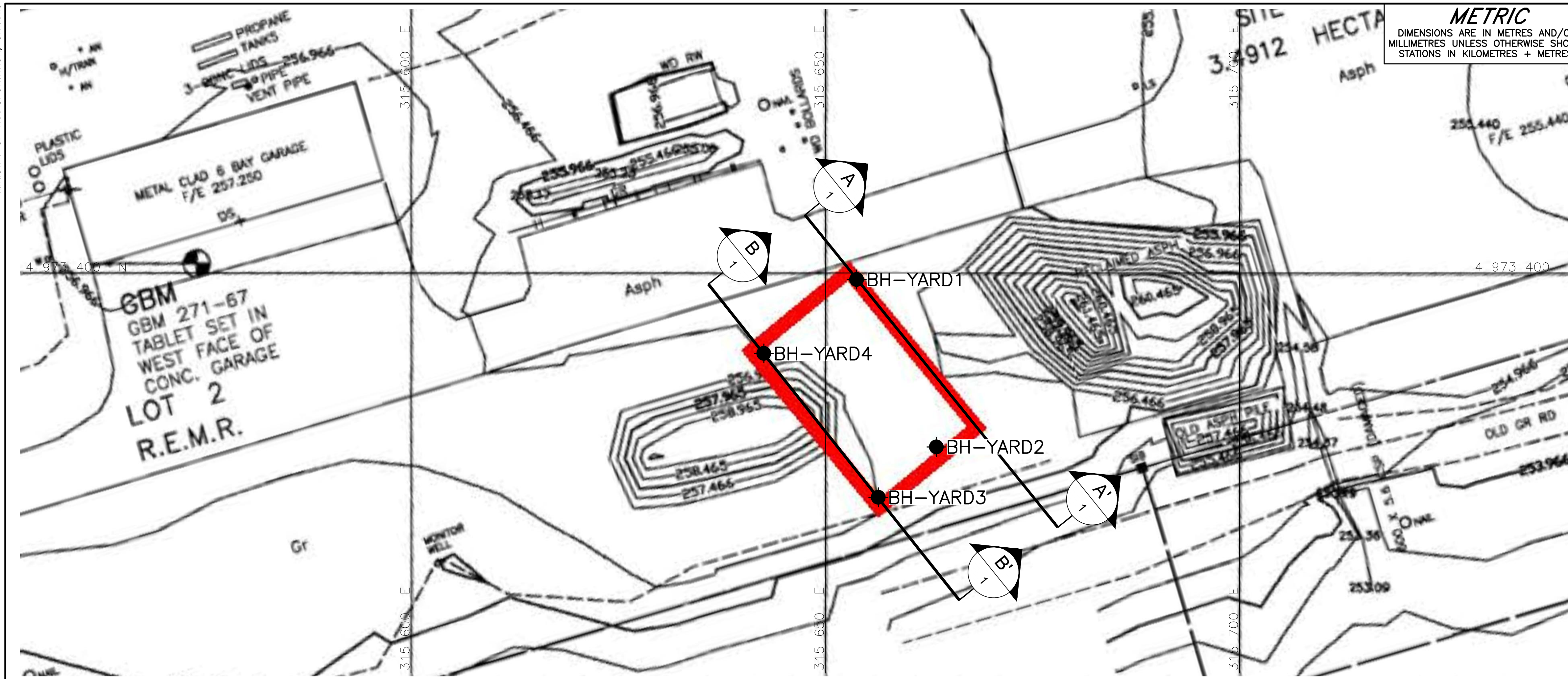
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
WO No. 2014-11033

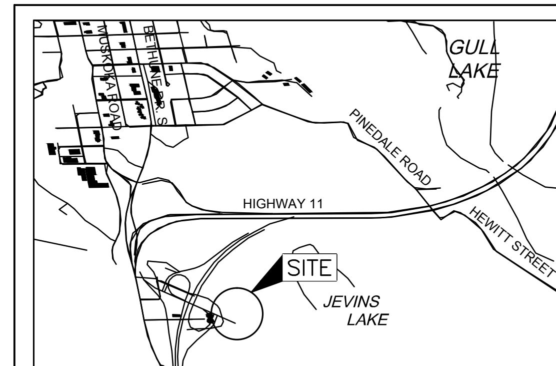
SHEET

SAND/SALT STORAGE STRUCTURE
GRAVENHURST PATROL YARD
BOREHOLE LOCATIONS AND SOIL STRATA

Golder Associates



PLAN
SCALE
6 0 6 12 m



KEY PLAN

LEGEND

●	Borehole – Current Investigation
N	Standard Penetration Test Value
16	Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
▽	WL upon completion of drilling

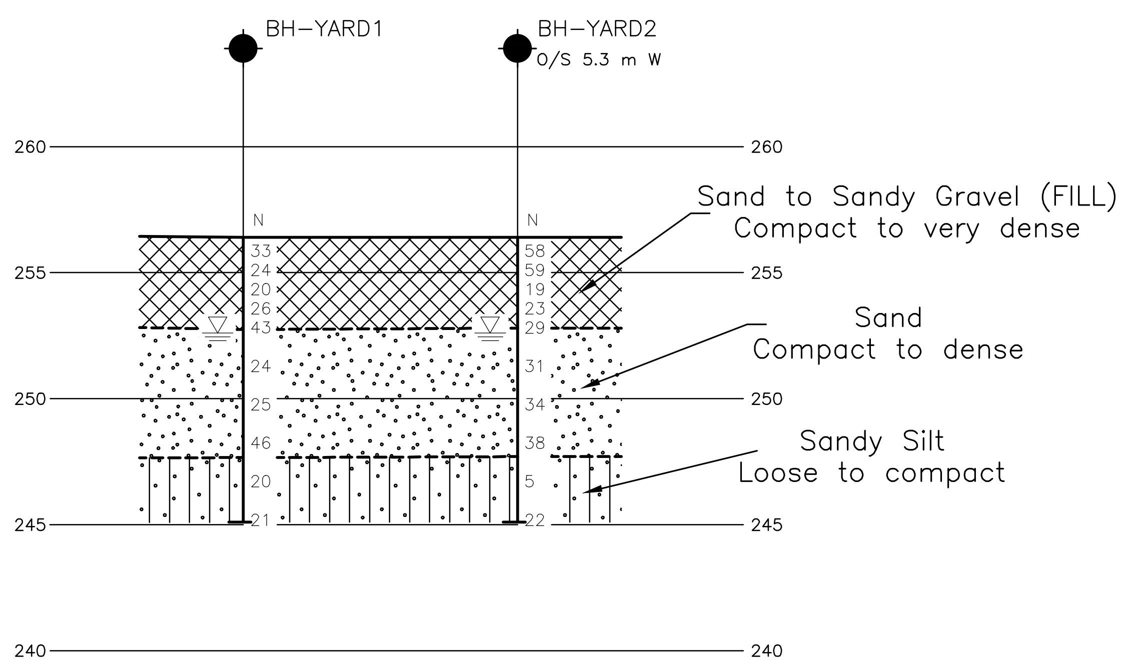
BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
BH-YARD1	256.4	4973399.2	315653.8
BH-YARD2	256.4	4973379.0	315663.4
BH-YARD3	256.6	4973372.9	315656.4
BH-YARD4	256.8	4973390.3	315642.6

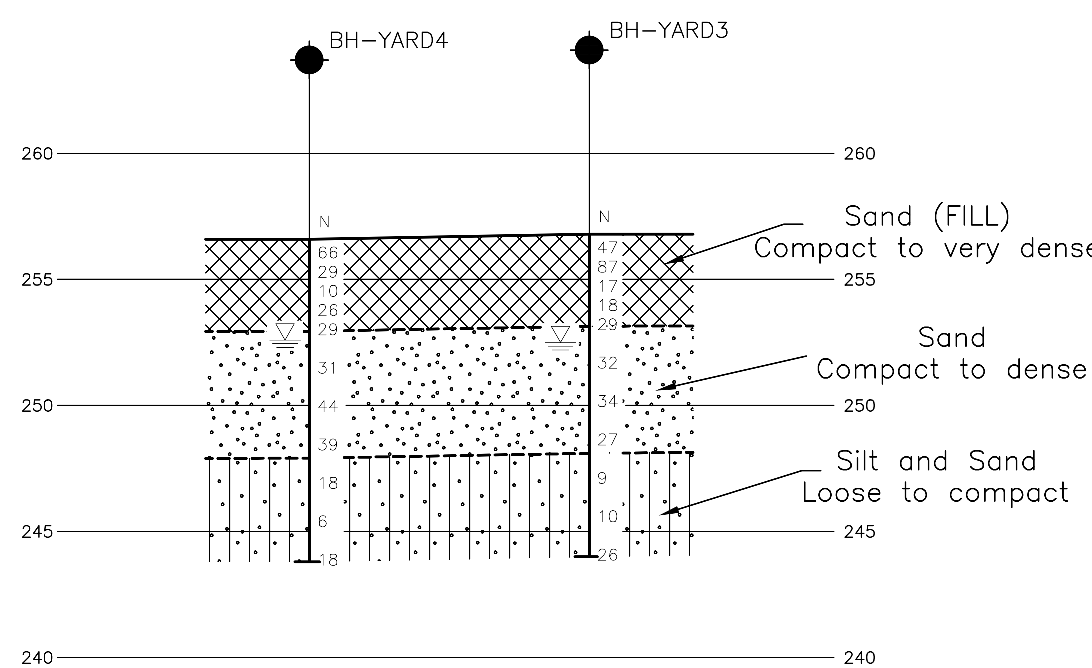
NOTES
This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

The complete Foundation Investigation for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS General Conditions.

REFERENCE
Patrol Facility Site Plan (Plan H-395-11-1) provided in digital format, drawing file no. Gravenhurst Patrol Yard PLAN.pdf, dated DEC 2012, received SEP 22, 2014.



A-A' 1 SECTION
HORIZONTAL SCALE 6 0 6 12 m
3 0 3 6 m VERTICAL SCALE



B-B' 1 SECTION
HORIZONTAL SCALE 6 0 6 12 m
3 0 3 6 m VERTICAL SCALE

LICENSED PROFESSIONAL ENGINEER S.E.M. POOT 90471921 OCT 03, 2014 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER J.M.A. COSTA OCT 03, 2014 PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION

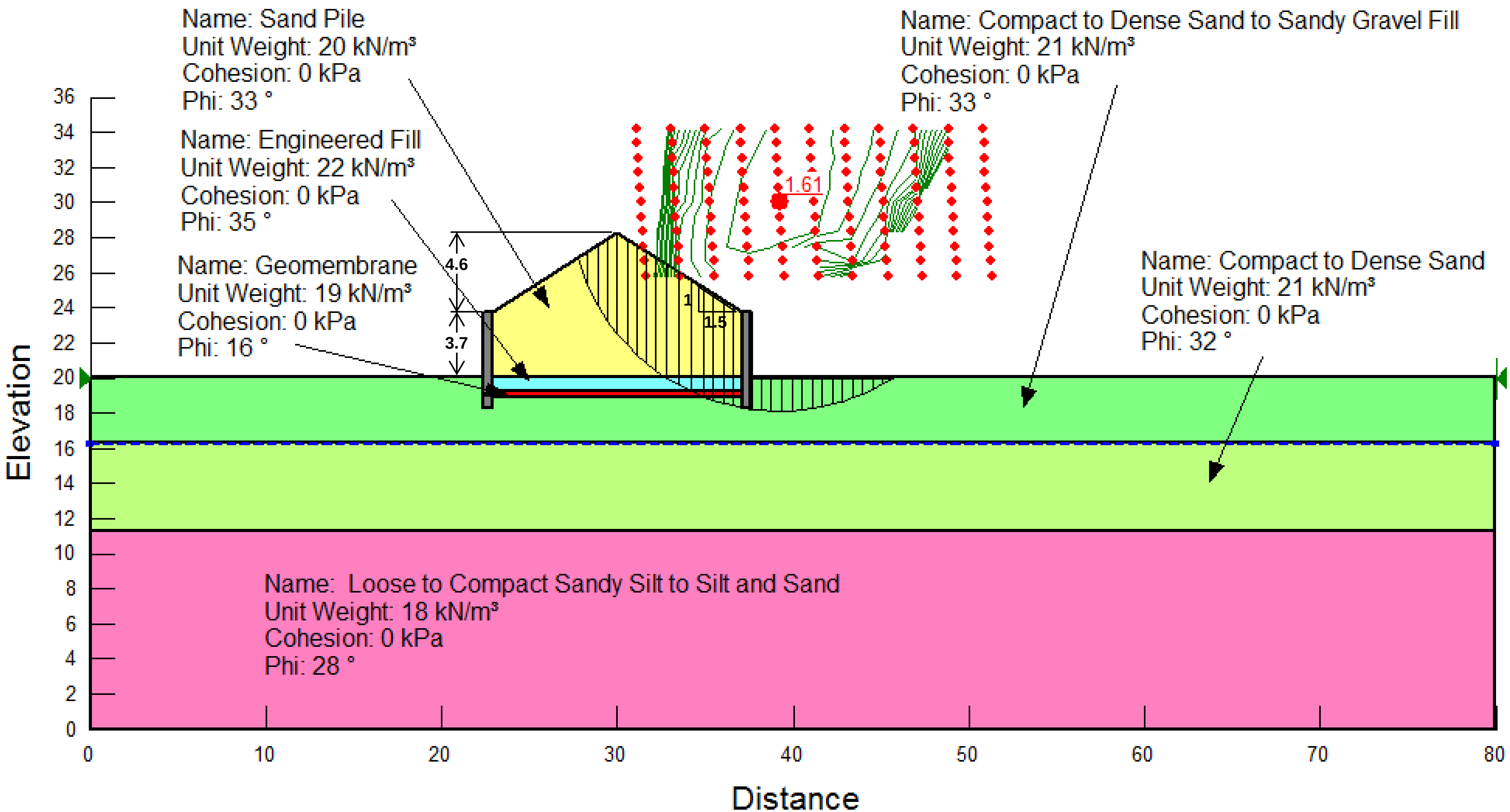
Geocres No. 31D-581

HWY. 11	PROJECT NO. 14-1181-0014		DIST.
SUBM'D. DM	CHKD.	DATE: 10/6/2014	SITE:
DRAWN: TB	CHKD. SEMP	APPD. JMAC	DWG. 1

PLOT DATE: October 6, 2014
FILENAME: \\golder.gds\gal\Sudbury\CAD-GIS\CAD\Projects\2014\14-1181-0014 Gravenhurst Patrol Yard\CIVIL 3D\1411810014 AA001.dwg

Sand/Salt Storage Structure, Gravenhurst Patrol Yard, Hwy 11
Global Stability Analysis

Figure 1

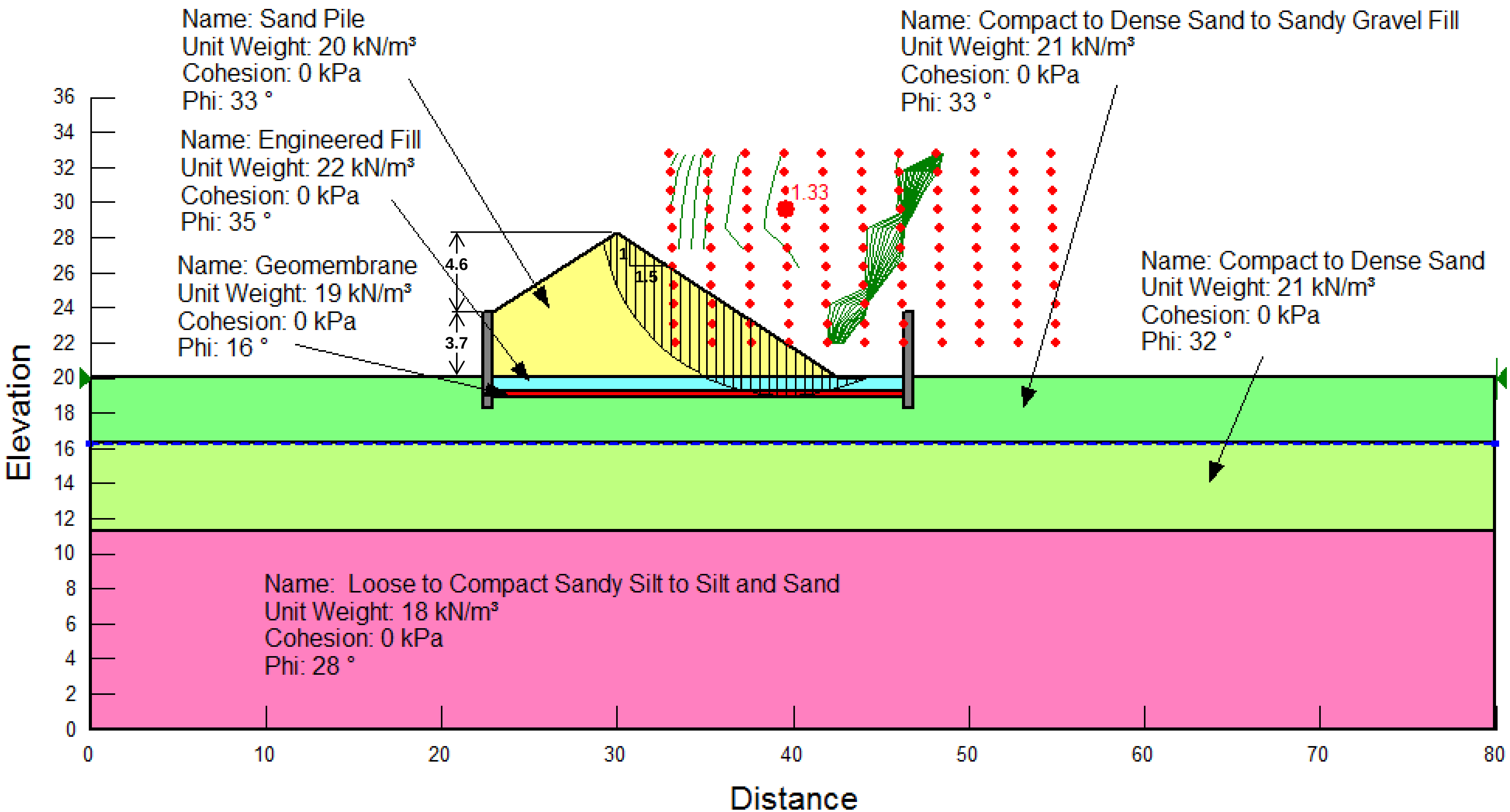


Date: October, 2014
Project No. 14-1181-0014.3000

Analysis By: DPM **Reviewed By:** SEMP

Sand/Salt Storage Structure, Gravenhurst Patrol Yard, Hwy 11
Stockpile Stability Analysis

Figure 2



Date: October, 2014
Project No. 14-1181-0014.3000

Analysis By: DPM **Reviewed By:** SEMP

Golder Associates

APPENDIX A

Record of Boreholes

LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

I. GENERAL

π	3.1416
ln x,	natural logarithm of x
$\log_{10}$	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time
FoS	factor of safety

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta\sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
υ	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
σ_1, σ_2, σ_3	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight)*
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation

* Density symbol is ρ. Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density multiplied by acceleration due to gravity)

(a) Index Properties (continued)

w	water content
w_l or LL	liquid limit
w_p or PL	plastic limit
I_p or PI	plasticity index $= (w_l - w_p)$
w_s	shrinkage limit
I_L	liquidity index $= (w - w_p) / I_p$
I_C	consistency index $= (w_l - w) / I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index $= (e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
C_α	secondary compression index
m_v	coefficient of volume change
c_v	coefficient of consolidation (vertical direction)
c_h	coefficient of consolidation (horizontal direction)
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation stress
OCR	over-consolidation ratio $= \sigma'_p / \sigma'_{vo}$

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction = tan δ
c′	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p′	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 - \sigma_3)$
S_t	sensitivity

Notes:
1. $\tau = c' + \sigma' \tan \phi'$
2. shear strength = (compressive strength)/2

LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

I. SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
SS	Split-spoon
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 300 mm (12 in.)

Dynamic Cone Penetration Resistance; N_d:

The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60º cone attached to “A” size drill rods for a distance of 300 mm (12 in.).

PH: Sampler advanced by hydraulic pressure
PM: Sampler advanced by manual pressure
WH: Sampler advanced by static weight of hammer
WR: Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm^2 pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

III. SOIL DESCRIPTION

(a) Non-Cohesive (Cohesionless) Soils

Density Index **Relative Density**	**N** **Blows/300 mm or Blows/ft**
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) Cohesive Soils

Consistency

	c_u, s_u **kPa**	c_u, s_u **psf**
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1,000
Stiff	50 to 100	1,000 to 2,000
Very stiff	100 to 200	2,000 to 4,000
Hard	over 200	over 4,000

IV. SOIL TESTS

w	water content
w_p	plastic limit
w_l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test[1]
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement[1]
D_R	relative density (specific gravity, G_s)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO_4	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
γ	unit weight

Note: 1 Tests which are anisotropically consolidated prior to shear are shown as CAD, CAU.

V. MINOR SOIL CONSTITUENTS

Per cent by Weight	**Modifier**	**Example**
0 to 5	Trace	Trace sand
5 to 12	Trace to Some (or Little)	Trace to some sand
12 to 20	Some	Some sand
20 to 30	(ey) or (y)	Sandy
over 30	And (non-cohesive (cohesionless)) or	Sand and Gravel
	With (cohesive)	Silty Clay with sand / Clayey Silt with sand

Golder Associates

RECORD OF BOREHOLE No BH-YARD1

METRIC

PROJECT 14-1181-0014
W.O. 2014-11033
LOCATION N 4973399.2; E 315653.8
ORIGINATED BY DM
DIST
HWY 11
BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers
COMPILED BY MT
DATUM GEODETIC
DATE September 3, 2014
CHECKED BY SEMP

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
256.4	GROUND SURFACE					
0.0	Sand to Sand and gravel, trace silt (FILL) Compact to dense Brown Moist	1	SS	33		32 61 (7)
		2	SS	24		
		3	SS	20		0 96 (4)
		4	SS	26		
252.8		5	SS	43		
3.6	SAND, trace silt Compact to dense Grey Moist to wet				▽	
		6	SS	24		0 96 4 0
	Sand heaving inside augers at 6.1 m depth.	7	SS	25		
247.7		8	SS	46		
8.7	Sandy SILT, trace clay Compact Brown Wet	9	SS	20		
245.1		10	SS	21		0 28 68 4
11.3	END OF BOREHOLE					

Notes:

1. Water level at a depth of 3.8 m below ground surface (Elev. 252.6 m) upon completion of drilling.

Column headings: SOIL PROFILE; SAMPLES; STRAT PLOT; ELEVATION SCALE (256–246); DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³.

+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH-YARD2

 METRIC

PROJECT 14-1181-0014			
W.O. 2014-11033	LOCATION N 4973379.0; E 315663.4		ORIGINATED BY DM
DIST	HWY 11	BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers	COMPILED BY MT
DATUM GEODETIC		DATE September 3, 2014	CHECKED BY SEMP

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
256.4	GROUND SURFACE
0.0	Sand to Sandy gravel, trace silt (FILL) Compact to very dense Brown Moist Recycled asphalt noted in Samples 1 and 2.
252.7 3.7	SAND, trace silt Compact to dense Brown Moist to wet
247.7 8.7	Sandy SILT, trace clay Loose to compact Grey Wet
245.1 11.3	END OF BOREHOLE Notes: 1. Water level at a depth of 3.8 m below ground surface (Elev. 252.6 m) upon completion of drilling.

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	58	
2	SS	59	71 27 (2)
3	SS	19	
4	SS	23	0 97 (3)
5	SS	29	
6	SS	31	0 99 (1)
7	SS	34	
8	SS	38	
9	SS	5	
10	SS	22	0 26 70 4

Ground water conditions: water level symbol at Elev. approx. 252.6 m.

Elevation scale: 256, 255, 254, 253, 252, 251, 250, 249, 248, 247, 246

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED; 20 40 60 80 100

PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60

UNIT WEIGHT γ kN/m³

+³, ×³: Numbers refer to Sensitivity; ○ 3% STRAIN AT FAILURE

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RECORD OF BOREHOLE No BH-YARD3

METRIC

PROJECT	14-1181-0014				
W.O.	2014-11033	LOCATION	N 4973372.9; E 315656.4	ORIGINATED BY	DM
DIST		HWY 11	BOREHOLE TYPE: 108 mm I.D. Continuous Flight Hollow Stem Augers	COMPILED BY	MT
DATUM	GEODETIC	DATE	September 4, 2014	CHECKED BY	SEMP

SOIL PROFILE | SAMPLES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100) | SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED (20, 40, 60, 80, 100) | PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) (20, 40, 60) | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS (GR SA SI CL)
256.6	GROUND SURFACE				
0.0	Sand, trace to some gravel and silt (FILL) Compact to very dense Brown to black Moist Recycled asphalt noted in Samples 1 and 2.	1	SS	47	
		2	SS	87	
		3	SS	17	10 90 (10)
		4	SS	18	
		5	SS	29	
252.9 3.7	SAND, trace silt Compact to dense Brown Moist to wet				
		6	SS	32	
		7	SS	34	0 93 (7)
		8	SS	27	
247.9 8.7	SILT and SAND, trace clay Loose to compact Grey Wet				
		9	SS	9	
	Layer of SILT of slight plasticity at 10.7 m depth.	10	SS	10	0 34 55 11
		11	SS	26	
243.8 12.8	END OF BOREHOLE Notes: 1. Water level at a depth of 4.3 m below ground surface (Elev. 252.3 m) upon completion of drilling.				

Elevation scale: 256, 255, 254, 253, 252, 251, 250, 249, 248, 247, 246, 245, 244

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No BH-YARD4

 METRIC

PROJECT 14-1181-0014
W.O. 2014-11033
LOCATION N 4973390.3; E 315642.6
ORIGINATED BY DM
DIST HWY 11
BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers
COMPILED BY MT
DATUM GEODETIC
DATE September 5, 2014
CHECKED BY SEMP

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
256.8	GROUND SURFACE					
0.0	Sand, trace silt, trace gravel (FILL) Compact Brown Moist Recycled asphalt noted in Sample 1.	1	SS	66		
		2	SS	29		5 90 (5)
		3	SS	10		
		4	SS	26		0 97 (3)
		5	SS	29		
253.1 / 3.7	SAND, trace silt Dense Grey to brown Wet				∇ (Elev. 252.8)	
		6	SS	31		
		7	SS	44		0 93 (7)
		8	SS	39		
248.1 / 8.7	SILT and SAND, trace clay Loose to compact Grey Wet					
		9	SS	18		0 51 45 4
	Zone of CLAYEY SILT to SILT at 10.7 m depth.	10	SS	6		
		11	SS	18		
244.0 / 12.8	END OF BOREHOLE					

Notes:

1. Water level at a depth of 4.0 m below ground surface (Elev. 252.8 m) upon completion of drilling.

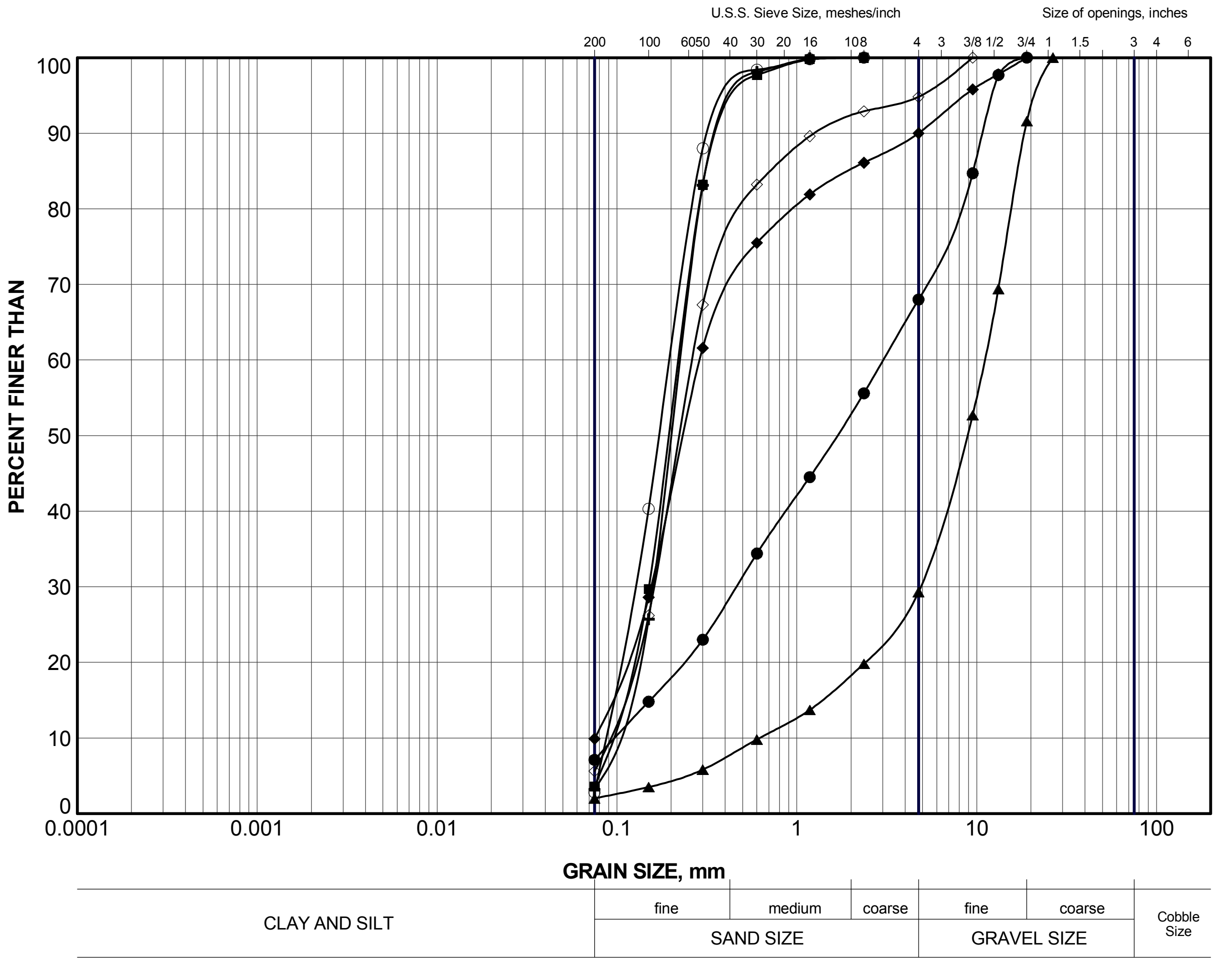
DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED; 20 40 60 80 100
PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L
WATER CONTENT (%): 20 40 60
UNIT WEIGHT γ kN/m³

ELEVATION SCALE: 256, 255, 254, 253, 252, 251, 250, 249, 248, 247, 246, 245, 244

+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

APPENDIX B

Laboratory Tests Results



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	BH-YARD1	1	256.1
■	BH-YARD1	3	254.6
▲	BH-YARD2	2	255.3
✚	BH-YARD2	4	253.8
◆	BH-YARD3	3	254.8
◇	BH-YARD4	2	255.7
○	BH-YARD4	4	254.2

PROJECT

HIGHWAY 11
SAND/SALT STORAGE STRUCTURE
GRAVENHURST PATROL YARD

TITLE

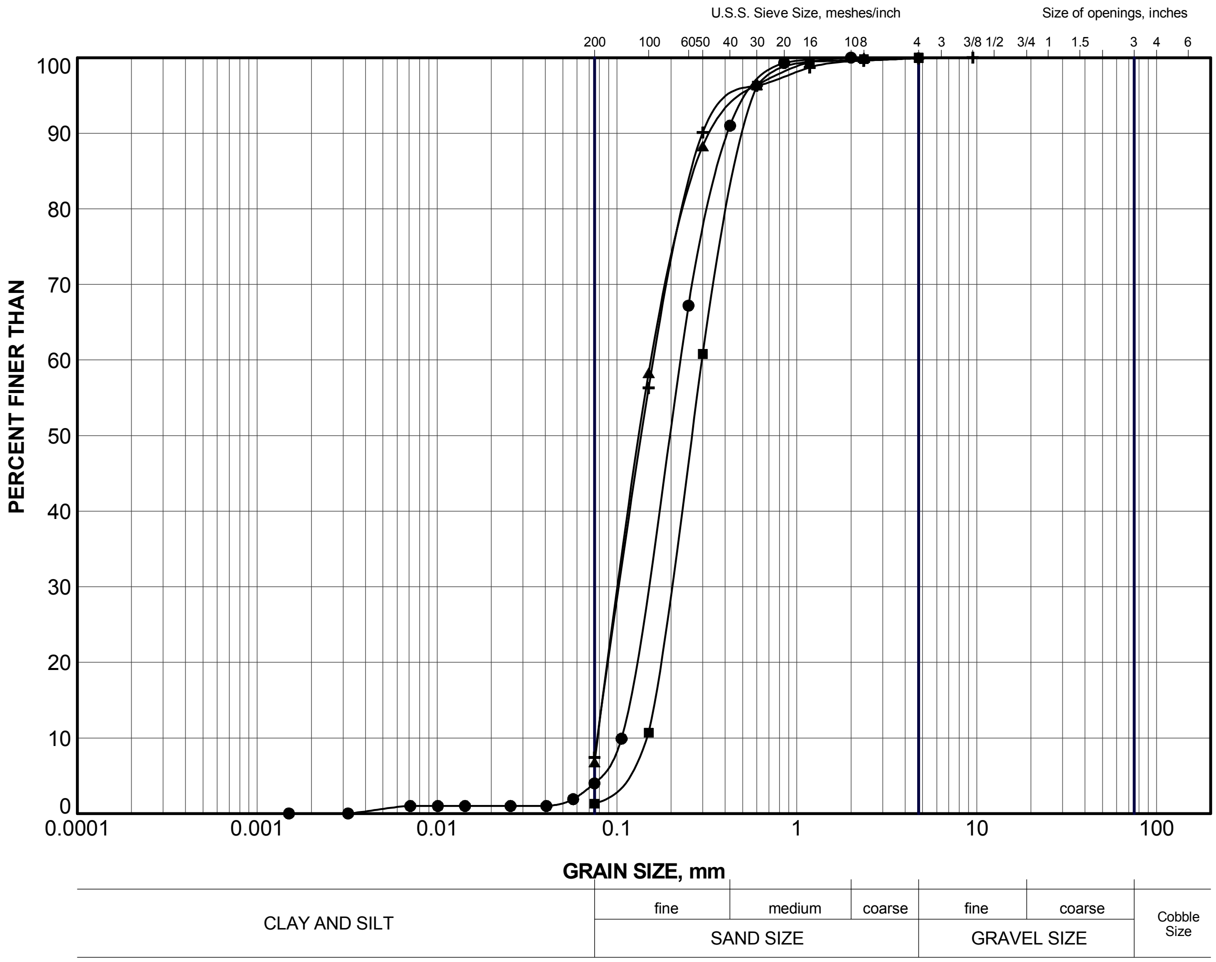
GRAIN SIZE DISTRIBUTION

SAND to SANDY GRAVEL (FILL)

Golder Associates
SUDBURY, ONTARIO

PROJECT No.	14-1181-0014		FILE No.	14-1181-0014.GPJ
DRAWN	TB	Sep 2014	SCALE N/A	REV.
CHECK	SEMP	Sep 2014		
APPR	JMAC	Sep 2014	FIGURE B1	

SUD-MTO GSD (NEW) GLDR_LDN.GDT



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	BH-YARD1	6	251.5
■	BH-YARD2	6	251.5
▲	BH-YARD3	7	250.2
✚	BH-YARD4	7	250.4

PROJECT

HIGHWAY 11
SAND/SALT STORAGE STRUCTURE
GRAVENHURST PATROL YARD

TITLE

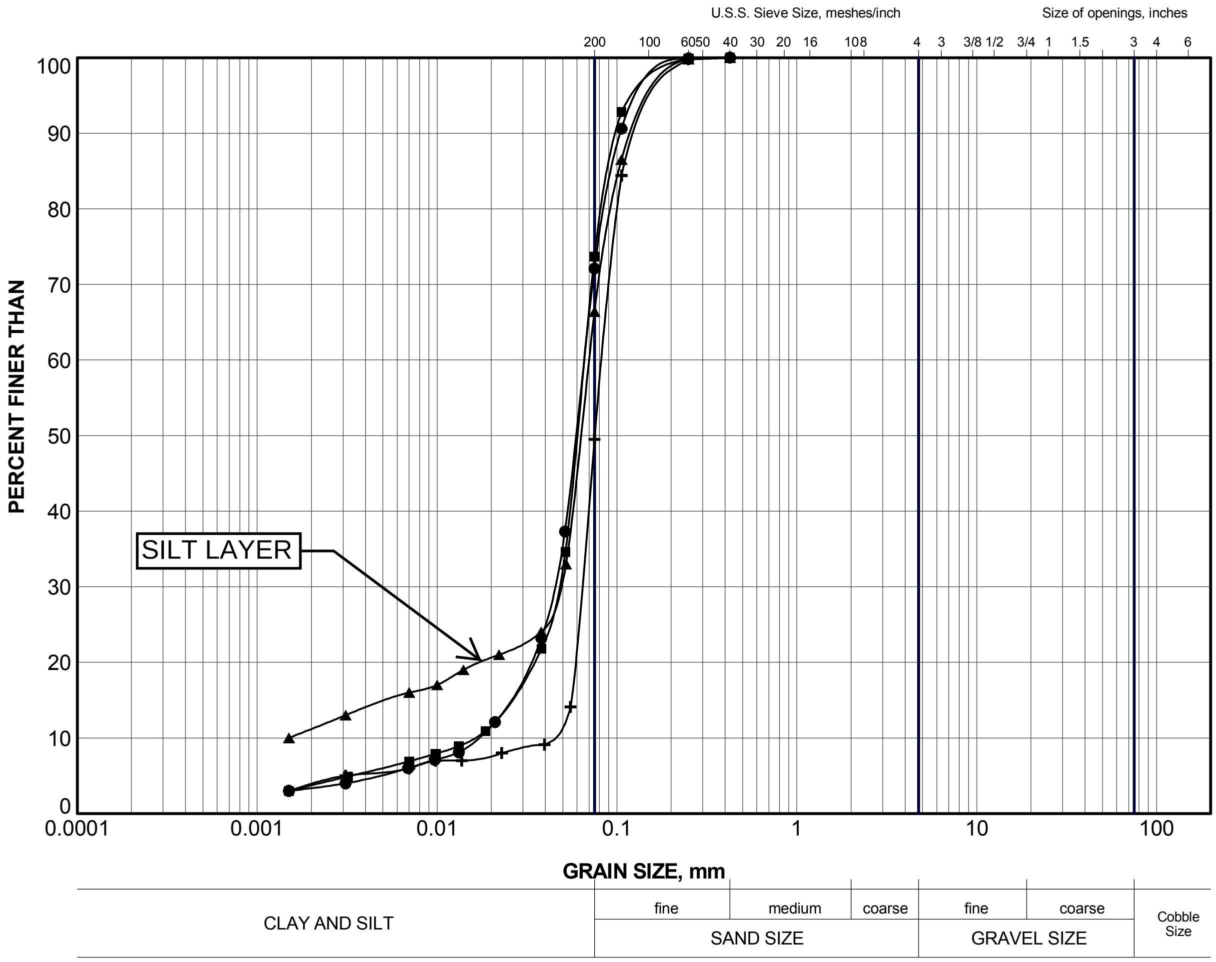
GRAIN SIZE DISTRIBUTION

SAND

Golder Associates
SUDBURY, ONTARIO

PROJECT No.	14-1181-0014		FILE No.	14-1181-0014.GPJ
DRAWN	TB	Sep 2014	SCALE N/A	REV.
CHECK	SEMP	Sep 2014		
APPR	JMAC	Sep 2014	FIGURE B2	

SUD-MTO GSD (NEW) GLDR_LDN.GDT



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	BH-YARD1	10	245.4
■	BH-YARD2	10	245.4
▲	BH-YARD3	10	245.6
+	BH-YARD4	9	247.4

PROJECT

HIGHWAY 11
SAND/SALT STORAGE STRUCTURE
GRAVENHURST PATROL YARD

TITLE

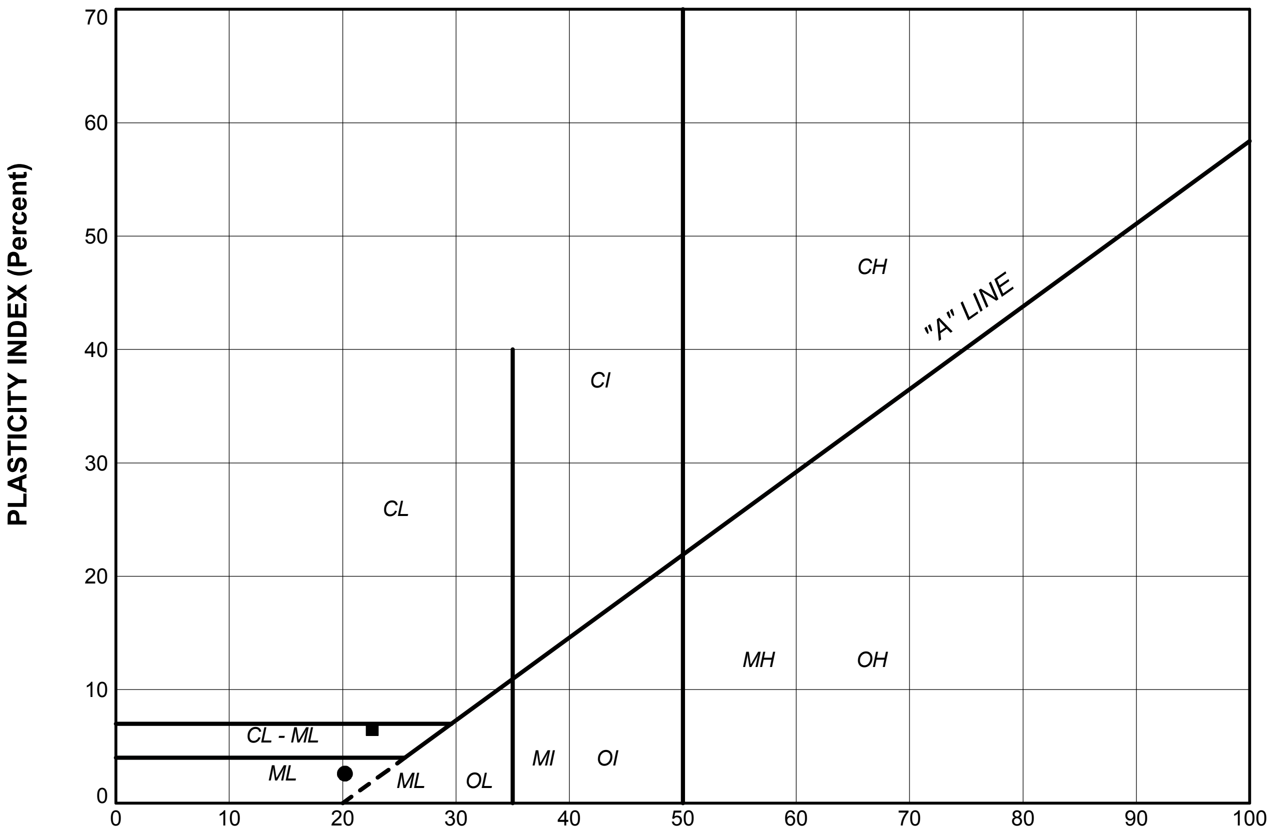
GRAIN SIZE DISTRIBUTION

SANDY SILT to SILT and SAND

PROJECT No.		14-1181-0014	FILE No.	14-1181-0014.GPJ
DRAWN	TB	Sep 2014	SCALE N/A	REV.
CHECK	SEMP	Sep 2014		
APPR	JMAC	Sep 2014	**FIGURE B3**	

Golder Associates
SUDBURY, ONTARIO

SUD-MTO GSD (NEW) GLDR_LDN.GDT



SOIL TYPE
C = Clay
M = Silt
O = Organic

PLASTICITY
L = Low
I = Intermediate
H = High

LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	BH-YARD3	10	20.2	17.6	2.6
■	BH-YARD4	10	22.6	16.1	6.5

PROJECT
HIGHWAY 11
SAND/SALT STORAGE STRUCTURE
GRAVENHURST PATROL YARD

TITLE
PLASTICITY CHART
CLAYEY SILT and SILT (LAYERS)

Golder Associates
SUDBURY, ONTARIO

PROJECT No.	14-1181-0014		FILE No.	14-1181-0014.GPJ
DRAWN	TB	Sep 2014	SCALE N/A	REV.
CHECK	SEMP	Sep 2014		
APPR	JMAC	Sep 2014	**FIGURE B4**	

SUD-MTO PL (NEW) GLDR_LDN.GDT

APPENDIX C

Non-Standard Special Provisions

WORKING SLAB – Item No.

Non-Standard Special Provision

Scope of Work

This Special Provision covers the requirements for the supply and placement of a concrete working slab on a soil subgrade under the structure foundations for the sand/salt storage structure. The purpose of the working slab is to protect the subgrade from disturbance and loosening due to construction traffic and ponded water and also to provide a level working surface.

Construction

Protection of Founding Soil

- Following inspection and approval of the prepared soil subgrade by the Quality Verification Engineer, a working slab, with a minimum thickness of 100 mm shall be placed on the foundation subgrade as per the contract drawings and documents. The concrete shall have a minimum 28 day compressive strength of 20 MPa.

Unwatering carried out for the excavations shall be done in such a manner as to prevent any disturbance to the surrounding original soil.

Basis of Payment

Payment at the Contract Price for the above tender item includes full compensation for all labour, equipment and material to do the required work.

SAND FILL (COVER SOIL) ABOVE GEOMEMBRANE – item No.

Non-Standard Special Provision

Scope of Work

The scope of work for the above noted tender item includes the supply and placement of sand fill above the geomembrane. This specification is also to alert the contractor that specialized equipment or construction techniques are required for placing and compacting all fill materials above the geomembrane.

Materials

Sand fill placed directly above and below the geomembrane will meet OPSS.PROV 1004 (Aggregates - Miscellaneous) Winter Sand, or OPSS.PROV 1002 (Aggregate – Concrete) Fine Aggregates.

At least two weeks prior to delivery of the cover soil to the site, the Contractor shall submit to the Contract Administrator the results of a grain size distribution analysis (sieve and hydrometer) performed on a representative sample of the cover soil material.

The source and quality of the sand fill material must be approved by the Contract Administrator prior to delivery of the material to site.

Construction

The Contractor must submit a list of equipment and proposed methods for placement of the sand fill (cover soil) above the geomembrane to the Contract Administrator at least two weeks prior to commencement of work. If equipment and/or methods prove unsatisfactory, the Contractor will implement changes required to ensure proper completion of work.

The sand fill must be spread with a low ground-pressure bulldozer or equivalent (maximum ground pressure of 35 kPa). A minimum of 300 mm separation distance must be maintained between the bulldozer tracks and the top of the geomembrane. The compacted density of the cover soil shall be great than or equal to 95% of the Standard Proctor Maximum Dry Density.

Truck traffic will be restricted to temporarily thickened areas of the cover soil layer providing a minimum separation distance of 900 mm between the truck tires and the underlying geomembrane.

Vary the bulldozer traffic path and operate equipment with care and under controlled speed, keeping turning radii as large as possible.

Repair any damage (i.e. tears, punctures) to the geomembrane liner caused during placement of the cover soil layer. The liner repair work shall involve uncovering the damaged areas and patching to a minimum distance of 1 m all around the tear or puncture.

Construction Quality Assurance

Samples of the sand fill received at the site will be taken for analysis of grain size distribution by the CQA Consultant. The sampling frequency will be one sample per 500 m3 of cover soil received at the site or one sample if the source changes. The results of the analysis shall meet the requirements given in this specification. Material not meeting the project specification must be removed from the site by the Contractor at no cost to the Owner.

The CQA Consultant will inspect the placement of the cover soil, with particular attention given to the thickness of the cover soil layer and the action of the spreading and hauling equipment on the construction surface.

The CQA Consultant will check the thickness of the cover soil layer and carry out testing for percent compaction using a Nuclear Density Gauge at a minimum frequency of 1 test per 500 m^2.

Basis of Payment

Payment at the contract price for the above noted tender item includes full compensation for all labour, equipment and materials to do the required work.

DEWATERING FOR EXCAVATIONS – Item No.

Non-Standard Special Provision

Scope

The contractor shall be alerted that the soils at the Highway 11 Gravenhurst Patrol Yard site consist of water-bearing sand and silts. Foundation elements requiring construction below the groundwater level must be carried out in the dry. The excavation shall be kept stable during the work.

It should be noted that water levels within the area are known to fluctuate. As a result, it is recommended that excavation for the foundations or any other element be performed in mid to late summer.

Basis of Payment

Payment at the contract price for the above tender item shall be full compensation for all labour, equipment and materials required to do the work.

As a global, employee-owned organisation with over 50 years of experience, Golder Associates is driven by our purpose to engineer earth's development while preserving earth's integrity. We deliver solutions that help our clients achieve their sustainable development goals by providing a wide range of independent consulting, design and construction services in our specialist areas of earth, environment and energy.

For more information, visit golder.com

Africa	+ 27 11 254 4800
Asia	+ 86 21 6258 5522
Australasia	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 56 2 2616 2000

solutions@golder.com
www.golder.com

Golder Associates Ltd.
1010 Lorne Street
Sudbury, Ontario, P3C 4R9
Canada
T: +1 (705) 524 6861